CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: May 25, 1951 Released: June 15, 1951

TRANS WORLD AIRLINES, INC., NEAR CAIRO, EGYPT, AUGUST 31, 1950

THE ACCIDENT

Number 3 engine failed on Trans World Airlines' Flight No 903 of August 30, 1950, near Cairo, Egypt A fire resulted, and the aircraft was turned back as if to land at Cairo The fire increased, the burning engine fell free and an attempted landing on the desert at about 0003Z* on August 31 resulted in destruction of the aircraft and death to all 48 passengers and 7 crew members

HISTORY OF THE FLIGHT

Flight 903 of August 30, a Lockheed Constellation, N 6004C, originated at Bombay, India Its destination was New York, New York, with several intermediate scheduled stops Departure from Bombay was at 0834 and arrival at Cairo at 2217

A complete crew change was made at Cairo and the aircraft was fueled to a total of 3,500 gallons When ready for takeoff the aircraft's total weight was 99,557 pounds, as compared to the maximum allowable weight of 107,000 pounds, and its center of gravity was located within specified limits

The weather over the route was good and the flight departed the Farouk Airport, Cairo, at 2335, August 30, planning to cruise at an altitude of 14,500 feet

The following routine position report was received from the flight by the Cairo control tower at 2355, "off Cairo 2335 25 miles out of Cairo at 2343 estimated time of arrival Rome 0530 " This message was acknowledged but the flight did not reply with the customary "Roger '' No other message was received from the flight despite frequent attempts to contact it by several stations

At or about the time of the receipt of the above message a number of persons on the desert to the northwest of Cairo saw the aircraft afire in flight The aircraft's position at that time was about 67 miles from Cairo, and on course, and its altitude was approximately 10,000 feet These persons were interviewed and statements were taken from 11 of them From these statements and from other evidence the flight path can be readily reconstructed with a high degree of probability, as follows

From the time the fire was first seen from the ground, at or about the time of the position report, the aircraft continued on course for about 10-1/2 miles It then turned to the left, still burning, and descended heading back in the general direction of Cairo Approximately 13-1/2 miles along this reverse course the burning engine fell to the desert the flight reduced its rate of descent, assumed a heading of about 210 degrees (about 90 degrees to the right of the course for Cairo), and held this heading, still burning until it struck the ground in a relatively flat position at a point about 52 miles to the northwest of Farouk Airport Widespread disintegration of the aircraft and a general fire resulted

At approximately 0800 the following morning the wreckage was sighted by another Trans World Airlines' aircraft

INVESTIGATION

The accident occurred at 0003, this was established by the readings of a number of personal timepieces that had been damaged and stopped at the instant of crash The weather at the time was excellent and was not contributory to the accident

The aircraft struck while under control and nearly level laterally, with the right wing slightly depressed, and a slight nose-down attitude suggesting that there had been no flare-out as the aircraft approached the ground Contact with the ground was made with the landing gear and flaps retracted

*All times referred to herein are Z (Greenwich) and based on the 24-hour clock

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The aircraft was severely damaged at the time of initial contact and almost completely disintegrated before its forward speed was checked Debris was scattered over an area stretching fan-wise for about 700 feet All occupants of the aircraft were found within this area Autopsies performed on the bodies of both the captain and the copilot disclosed that neither had breathed flame or hot gas, indicating that there had not been any fire in the cockpit prior to the crash

The wing fuel tanks burst at impact with the result that fuel was splashed ahead and over most of the fan-shaped area defining the debris Practically all of the various parts that came to rest within this area, with the exception of those that had been buried in the sand, were damaged or destroyed by the resulting fire

The emergency fuel shut-off valve for No 3 engine was found in the closed position

This aircraft normally carries six fire extinguishing bottles (CO_2) Only four of the six were found; examination disclosed that all four had been discharged prior to impact None of the small emergency fire extinguisher bottles carried within the fuselage had been discharged prior to impact

A thorough examination of the aircraft's entire control system showed no evidence or any suggestion of any failure or malfunctioning prior to the crash with the exception of the probable loss of aileron boost

A thorough examination of the aircraft's electrical system and of its radio equipment disclosed no evidence of malfunctioning or arcing prior to impact

Engines Nos 1, 2 and 4 and their respective propellers were recovered in the close proximity of the crash site Examination of all three of these power units indicated that the three engines had been developing power and the three propellers were in forward pitch at the time of the crash There is no evidence to suggest any malfunctioning of any of these three power plants

The No 3 engine, with its propeller and engine mount, was recovered back along the flight path at a distance of about 3 5 miles from the impact site The point of severance from the aircraft was at the nacelle barrel attaching points flush with the firewall An inspection of No 3 propeller and its dome revealed no evidence of failure in flight prior to the engine falling free of the aircraft Investigation revealed that the propeller was within 3-1/2 degrees of the full feathering position Between the main wreckage and the No 3 engine many pieces of molten metal were recovered Distribution of this molten metal indicated a flight direction of approximately 210 degrees These pieces were identified as having come from the top surface of the wings in the general vicinity of, and behind, No 3 engine

The No 3 power unit was examined at Cairo and later brought to LaGuardia Airport, New York, New York There the entire power unit was reconstructed as much as it could be considering that some parts had been destroyed by fire One purpose of this reconstruction was to determine the genesis and path of the fire This subject will be discussed later

The engine itself was completely disassembled Although internal damage was severe and widespread, it was possible to determine the sequence of failures and breakage The main failure was the rear master rod bearing As the engine continued operating the rear crank pin overheated and collapsed The bearing failure and the crank pin collapse progressed until there was approximately an inch difference in the diameters of the two This condition allowed the effective piston stroke to increase until the pistons were striking valves and cylinder heads All rear articulated rods and the rear master rod then failed

This general failure caused much external damage at the rear row of cylinders and the crankcase As the rear master and articulated rods sliced through the walls of the rear cylinders, the mating sections of the rear crankcase were appreciably displaced This in turn distorted and displaced the inter-zone baffle, commonly known as the fire seal, which is an annular disk immediately aft of the rear row of cylinders Damage to this baffle was enough to destroy its function as a means of preventing the spread of fire

Throughout the engine various bearing surfaces showed considerable operational damage which was evidenced by metal pick-up, by metal displacement and by heat discoloration, a condition unquestionably caused by lack of

lubrication This condition also indicates that the engine continued to rotate for some time after the failure of the rear master rod bearing, which failure resulted in a loss of oil pressure, and lubrication, throughout the engine

In discussing the pattern and path of the fire it seems desirable to state where fire seals are placed in reference to the engine nacelle As mentioned earlier, there is an annular disk made of a fireproof material surrounding the rear accessory section of the engine at a point immediately aft of the rear row of cylinders It extends radially to the cowling The entire region forward of this baffle is known as Zone No 1 The entire region aft of this baffle extending back to the firewall is known as Zone No 2 The entire region aft of the firewall and including the rest of the nacelle is known as Zone No 3 Both the baffle and the firewall serving as the front and rear limits, respectively, of Zone No 2 are of fireproof material, but there is also fireproof material enclosing Zone No 2 circumferentially

An analysis of the pattern and path of the fire required differentiation between fire in flight and fire following impact Although it was not possible to make this differentiation in all instances, it was accomplished with enough degree of probability to indicate the fire growth The flailing of broken master or articulated rods at the mating sections of the crankcase in the plane of the rear row of cylinders actually cut away a section of the crankcase This distorted and destroyed the effectiveness of the interzone baffle lying immediately aft The general breakage was so widespread that more than one line carrying inflammable fluid was severed and lubricating oil and oil fumes from the crankcase were liberated profusely Fire resulted This fire was relatively light in Zone No 1 but so severe in Zone No 2 that it melted the adjoining dural structure rearward of the firewall, in zone 3, allowing the engine to fall free The fire than continued through Zone No 3 and the adjacent wing structure, leaving aft of the rear spar through the top skin of the wing The result was that numerous parts of the secondary wing structure also burned free and fell This accounts for the general line of small molten and burned pieces found between No 3 engine and the main wreckage

The subject engine (No 3) had not reached its first overhaul period It had been operated approximately 1,100 hours since installation when new The specified overhaul period for this model engine is 1,200 hours At the time of the accident the engine oil had not been changed but merely added to as required, which was company procedure and accepted good practice at that time

A thorough analysis of maintenance records and flight logs disclosed only one item which may be significant in connection with this accident The item was that approximately 18 hours before the accident, while the subject aircraft was en route from Cairo to Bombay, No 3 engine experienced a temporary unusually high difference in the temperatures of the in-flowing and the out-flowing oil of the engine This was logged by the flight engineer as were, of course, many other routine readings The difference was approximately 40 degrees C between the temperature of oil to the engine and oil from the engine This was not considered by the operator to be indicative of potential trouble inasmuch as the carrier itself had arbitrarily set a differential of 45 degrees C as a safe spread The engine manufacturer does not specify a maximum spread between the oil in and the oil out temperatures but merely sets the figure of 83 degrees C as the maximum allowable for in-flowing oil under cruising conditions, which may be exceeded temporarily during takeoff and climb Records indicate that none of the engines of this aircraft had operated under cruising conditions with oil in temperatures higher than this figure

Most internal combustion engines gradually accumulate a deposit of a hard substance known as sludge in the outer portions of all hollow crank pins which act as centrifuges This material is composed mostly of lead from the fuel plus a number of other substances presumably from the oil and possibly from metal surfaces The subject engine exhibited the usual amount of this sludge which was caked and hard

Further investigation of this engine revealed that No 9 piston was burned on the

exhaust side through the ring belt and skirt section Both the front and rear balancers had seized on their respective sleeves resulting in the driving pinion gears of both balancers being stripped There were some indications that the rear balancer had been malfunctioning for an appreciably longer period of time than the front balancer However, the nature of this damage was such that it is impossible to put a time figure upon the duration of the malfunctioning

ANALYSIS

A careful review of all of the evidence indicated that the immediate cause of the major damage to the rear row power section with its resulting fire was failure of the rear master rod bearing However, the failure resulted in such extensive damage to both the bearing and the crank pin, causing wear of approximately one inch difference in their diameters, that it was impossible to determine positively the primary cause of the master rod bearing failure, i e , the damage was so severe that it eliminated the evidence

From facts learned during this investigation there appear to be three possibilities as to what may have initiated the failure of the master rod bearing They will be discussed in the order of increasing likelihood

First, No 9 piston was burned It appears that although the appearance and location of the burn was somewhat similar to what would be expected of a failed piston, it is believed that such a failure would have been evident by loss of power and of oil before contaminated oil could have reached the master rod bearing and initiate its total failure Also, other pistons were damaged, exclusive of the burning, in the same areas as the No 9 piston Thus it appears that a piston failure did not initiate the failure of the master rod bearing

Second, is the possibility of internal engine damage occurring at the time of the unusually high oil temperature difference which was logged approximately 18 hours before the accident This temperature difference unquestionably indicated some abnormality in the operation of the engine It is possible that a balancer seized, causing this high oil temperature, and that the subsequent stripping of the balancer's pinions rendered the balancer inoperative, allowing the oil temperature difference to return to normal Had this occurred there would have been no way for the flight crew to know of the failure inasmuch as the function of these balancers is to inhibit vibratory stresses throughout the power plant and these vibratory stresses are of such a nature that they do not manifest themselves to the crew Continuing with this possibility, metallic parts from the failed balancer and its pinions could have been introduced into the lubricating oil system and carried to the rear master rod bearing, thus initiating the failure of that bearing This series of events remains as a slight possibility

Third is the matter of sludge In connection with the accumulation of sludge within the crank pins of this engine, it has been found in general that such an accumulation as was found is not dangerous providing the sludge remains solid and does not break away Sludge normally does remain solidified A study of sludge accretion in this model engine discloses that after about 700 hours of operation, the sludge level reaches the tops of the oil feed tubes within the crank pins When this occurs the scouring effect and/or the increased oil velocity through the smaller passageway tends to prevent more accretion Providing that the sludge does not become dislodged it is unlikely that it will interfere with the master rod bearing lubrication However, under certain conditions caked sludge may shift or break up and obstruct oil flow to a master rod bearing There have been a number of master rod bearing failures attributed to just such an occurrence Therefore, and because the subject engine had been in operation for 1,100 hours, there must remain the distinct possibility that sludge obstruction of oil flow was the primary cause of the failure of the master rod bearing

During the investigation of this accident the effects of oil dilution were studied Oil dilution is the process of introducing a small amount of fuel into the lubrication system just before shutting down the engine

to lower oil viscosity and thus facilitate cold weather starting It is known that this can cause a loosening or breaking away, or softening, of caked sludge possibly resulting in the obstructing of oil flow However, the subject aircraft had not been used in cold weather since being placed in service in June 1950 As oil dilution had not been practiced it is eliminated as the initiating factor in the possible loosening of any sludge

As a result of this accident and previous failures of master rod bearings in the model 749C18BD1 engine, the following corrective measures were taken

1 The practice of no oil changes between engine overhaul has been discontinued Oil is now being changed at periods not to exceed 400 hours

2 Fine mesh main oil screens are now being service tested by Trans World Airlines It is believed that some contaminants now being carried into the engine lubricating system will be screened out

3 Longer master rod bearing oil feed tubes are currently being installed by Trans World Airlines in both the 745C18BA3 and 749C18BD1 engines This is an interim fix which will not be required when the new type crank pin sludge plug now under development is installed

4 It is believed use of a crank pin sludge plug which is under development will very effectively reduce the crank pin sludge accumulation to the point that it is of no consequence

5 A long range project is the development of a centrifuge, independent of the engine, for the separation of sludge from the oil This appears to be the most practical approach to the problem, however, the development period at best will be quite a long time

6 In March 1951, the subject carrier discontinued the practice of oil dilution in all similar engines, regardless of climate, as a result of accumulated data on master rod bearing failures, some of the data stemming from this investigation

Approximately six weeks after this accident, on October 6, 1950, the carrier issued to all pilots and flight engineers the following information

"It is pretty generally known that typical symptoms of the early stages of a master rod bearing failure are high oil temperature and low oil pressure, these two abnormal indications starting early in the failure and becoming continually more pronounced as the failure progresses The explanation for these typical symptoms is simple and direct

"As the bearing failure commences the clearance between the bearing surface and the crank pin journal increases rapidly thus permitting a much greater rate of oil flow through the engine Since the oil pumping capacity of most engines is not far above the value required for normal conditions in the engine, this increased oil flow will rapidly be indicated by a drop in oil pressure Inasmuch as the heat rejected to the oil is largely a function of the oil circulation, the greater the flow the greater the amount of heat the oil will absorb If the oil cooling capacity of the installation has only a slight margin above normal requirements the above condition will lead to a rapid increase in oil temperature

"In the C18BD series engine the manufacturer has finally developed an installation with extremely generous oil pumping capacity and oil cooling capacity This design feature naturally eliminates many oil temperature and pressure problems resulting from marginal installations However, by applying the reasoning in the preceding paragraph it is evident that the earlier steps of a master rod bearing failure will not be nearly so marked in terms of decrease in oil pressure and increase in oil temperature as they will be in a more marginal design Inasmuch as TWA and other operators have in recent months experienced a number of BD master rod bearing failures which were permitted to advance in flight to such a degree that the engines were badly mutilated, it seems desirable to remind all flight crews of the above facts and to urge their constant alertness to detect the first unmistakable signs of decreasing oil pressure and increasing oil temperature in these engines When these symptoms are observed the engine should be feathered A review of six such failures in TWA's and in other carriers' operation during the past few months shows that the failures all occurred during climb, that the symptoms were recognized

for an average of 12 minutes before feathering took place, and that in every case considerable damage resulted to the power section of the engine, not to mention the attendant hazard of total destruction of the power plant before feathering is accomplished

"Because of the very marginal oil flow and cooling capacity of the BA engine plus the much greater experience of domestic flight crews with master rod bearing failures these precautions are not so specifically applicable to the BA engine Experience has shown that a very marked drop in oil pressure and rise in oil temperature will always precede a master rod bearing failure and flight crews have generally responded promptly (with but a few isolated exceptions) Minor abnormalities in oil pressure and temperature on this engine may well be a direct result of the marginal design rather than an indication of bearing failure "

FINDINGS

On the basis of all available evidence the Board finds that

1 The carrier, the aircraft and the crew were properly certificated

2 The rear row master rod bearing of No 3 engine failed during the climb to cruising altitude

3 This bearing failure precipitated a fire in the No 3 power plant, the No 3 propeller was feathered

4 The aircraft was turned back toward Cairo and the burning engine shortly fell free

5 Fire continued in the right wing and an attempted night landing on the desert resulted in destruction of the aircraft

PROBABLE CAUSE

The Board determines that the probable cause of this accident was failure of the rear row master rod bearing causing an uncontrolled fire which precipitated a crash landing

BY THE CIVIL AERONAUTICS BOARD

/s/ OSWALD RYAN
/s/ JOSH LEE
/s/ JOSEPH P ADAMS
/s/ CHAN GURNEY

Donald W Nyrop, Chairman, did not participate in the adoption of this report

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Supplemental Data

INVESTIGATION AND HEARING

The Civil Aeronautics Board was notified of the accident involving Trans World Airlines, Inc , near Cairo, Egypt, by radio at 0730 EDT, August 31, 1950, and an inquiry was immediately initiated with the New York office of Trans World Airlines Two investigators from the Board's New York office were assigned as the official U S representatives of the Civil Aeronautics Board and proceeded to the scene of the accident Upon delegation of the investigation by the Egyptian Government to the United States Civil Aeronautics Board, an investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended A public hearing was ordered by the Board and was held in New York, New York on October 18 and 19, 1950

The Controller of Civil Aviation of Egypt attended the hearing, at the Board's invitation, as his government's official representative The Civil Aeronautics Board desires to express its appreciation of the full cooperation extended by the Egyptian Government during the investigation of this accident

AIR CARRIER

Trans World Airlines, Inc , is incorporated in the State of Delaware and maintains headquarters for its domestic and international divisions at Kansas City, Missouri Trans World Airlines possesses a certificate of public convenience and necessity and an air carrier operating certificate which authorize transportation by air of persons, property, and mail over the route described in this report

FLIGHT PERSONNEL

Captain Walton B Webb, age 45, held a valid airline transport rating No 10928 certified for h p ratings 160-12000, and a radio-telephone No 17-12694, Class R He was employed by TWA on July 1, 1940, and was promoted to captain, domestic, on September 1, 1943, and captain, international, on June 17, 1946 He had a total of 10,664 41 flying hours, of which 42 52 had been in 749A type aircraft, and 822 05 in 749 type aircraft His last instrument check was accomplished on August 20, 1950, last line check was May 7, 1950, and his last CAA physical examination was May 28, 1950 He completed his Constellation 749A training on April 17, 1950

First Officer H J Hammitt, age 34, held a valid airline transport rating No 42902, h p ratings 225-675, and a radio-telephone No Rp-17-17421 He was employed by TWA on September 12, 1945, and was made first officer on February 18, 1946 He had a total of 6355 04 flying hours, of which 56 49 had been in 749A type aircraft, and 307 42 in 749 type aircraft His last instrument check was completed July 11, 1950, and his last CAA physical examination was May 31, 1950 He completed his Constellation 749A training on April 18, 1950

Navigator H B Hackett, age 32, held a valid CAA certificate No 1073018 His total flying hours with TWA were 6,067 His last CAA physical examination was accomplished on November 18, 1949

The other crew members were Melvin C House, flight engineer, H J Stiles, flight radio officer, Jose Bernard, flight purser, and J Lorenzi, flight hostess

THE AIRCRAFT

N-6004C, a Lockheed Constellation Model 749A, had a total of 1100 45 flying hours and was currently certificated by the Civil Aeronautics Administration It was equipped with four Wright engines, Model 749C18BD1, and the propellers were Hamilton Standard, Model 43E60, equipped with 6869A-0 blades